Far-Infrared C-Axis Conductivity of $Pr_xY_{1-x}Ba_2Cu_3O_7$ Studied by Spectral Ellipsometry

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The c-axis conductivity of flux-grown, partially Pr-substituted $Pr_xY_{1-x}Ba_2Cu_3O_7$ single crystals has been measured using the technique of spectral ellipsometry [1]. We find that the c-axis response exhibits similar spectral features like in oxygen deficient and thus underdoped $YBa_2Cu_3O_{7-\delta}$ [2]. A spectral gap in the electronic conductivity develops already in the normal state for $T>>T_c$ (the value of σ_{1c} is reduced with decreasing temperature for $\omega \leq 2\Delta$). The size of the gap increases as a function of underdoping. The oxygen bond-bending phonon mode at 320 cm^{-1} exhibits a strongly anomalous T-dependence and a broad absorption peak forms at low temperature. These similarities between fully oxygenated Pr-substituted $Pr_xY_{1-x}Ba_2Cu_3O_7$ and deoxygenated $YBa_2Cu_3O_{7-\delta}$ suggests that the T_c suppression in the former is caused by a decrease of the hole concentration or a localization of the mobile hole carriers rather than by pair breaking. It also supports the previous suggestion that the unusual spectral features of the c-axis conductivity of Y-123 single crystals are determined by the CuO_2 planes, which confine the charge carriers [3]. The fully oxygenated and thus metallic CuO chains merely seem to affect the absolute value of the electronic conductivity, i.e. σ_{1c} is somewhat larger for $Pr_xY_{1-x}Ba_2Cu_3O_7$ with fully oxygenated CuO chains (as is evident from the absence of the apical defect mode at 630 cm^{-1}) than for $YBa_2Cu_3O_{7-\delta}$ crystals with a similar T_c value.

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References: [1] C. Bernhard *et al*., Phys. Rev. **B 62**, 9138 (2000). [2] C. Homes *et al*., Phys. Rev. Lett. **71**, 1645 (1993); C. Bernhard *et al*., Phys. Rev. **B 61**, 618 (2000). [3] C. Bernhard *et al*., Phys. Rev. Lett. **80**, 1762 (1998); Phys. Rev. **B 59**, R6631 (1999); Physica **C 317-318**, 276 (1999).

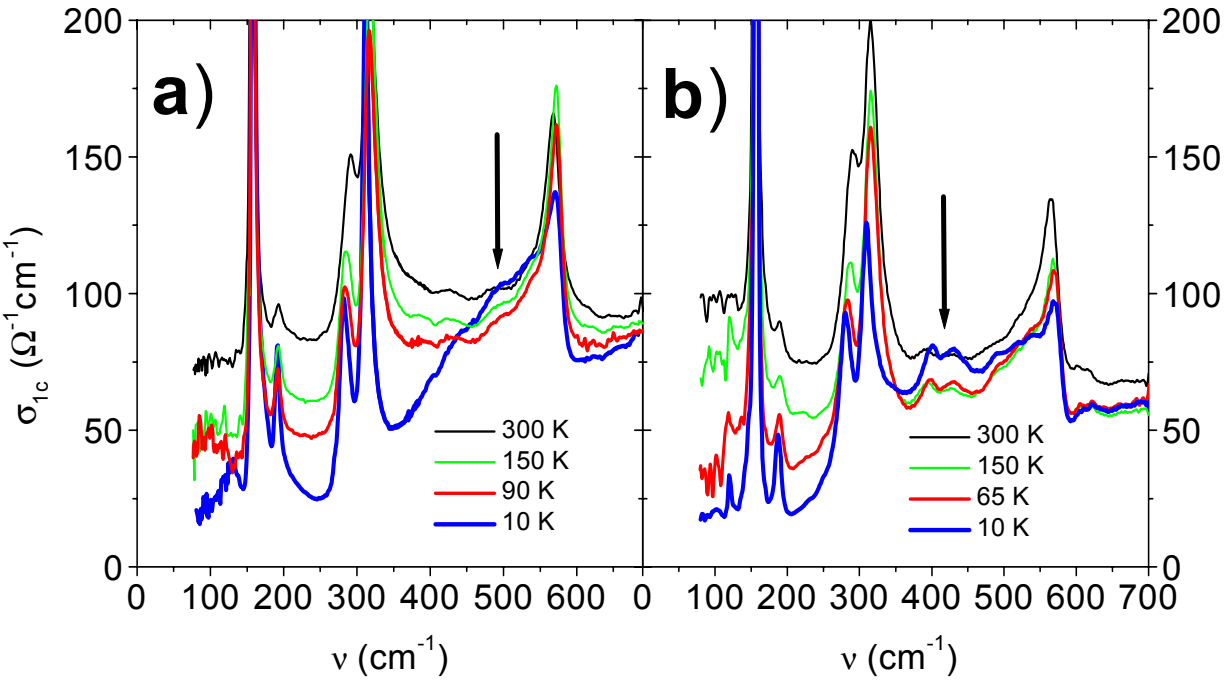

Figure 1. C-axis conductivity of (a) $Pr_{0.2}Y_{0.8}Ba_2Cu_3O_7$ with T_c=81 K and (b) $Pr_{0.3}Y_{0.7}Ba_2Cu_3O_7$ with T_c=63 K. It is evident that a spectral gap forms already in the normal state for $T>>T_c$. The phonon mode at 320 cm^{-1} exhibits an anomalous T-dependence and a broad absorption peak forms at low temperature as marked by the arrow.